

# Future World Oil Prices and the Potential for New Transportation Fuels



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<http://www.ott.doe.gov/facts.html>



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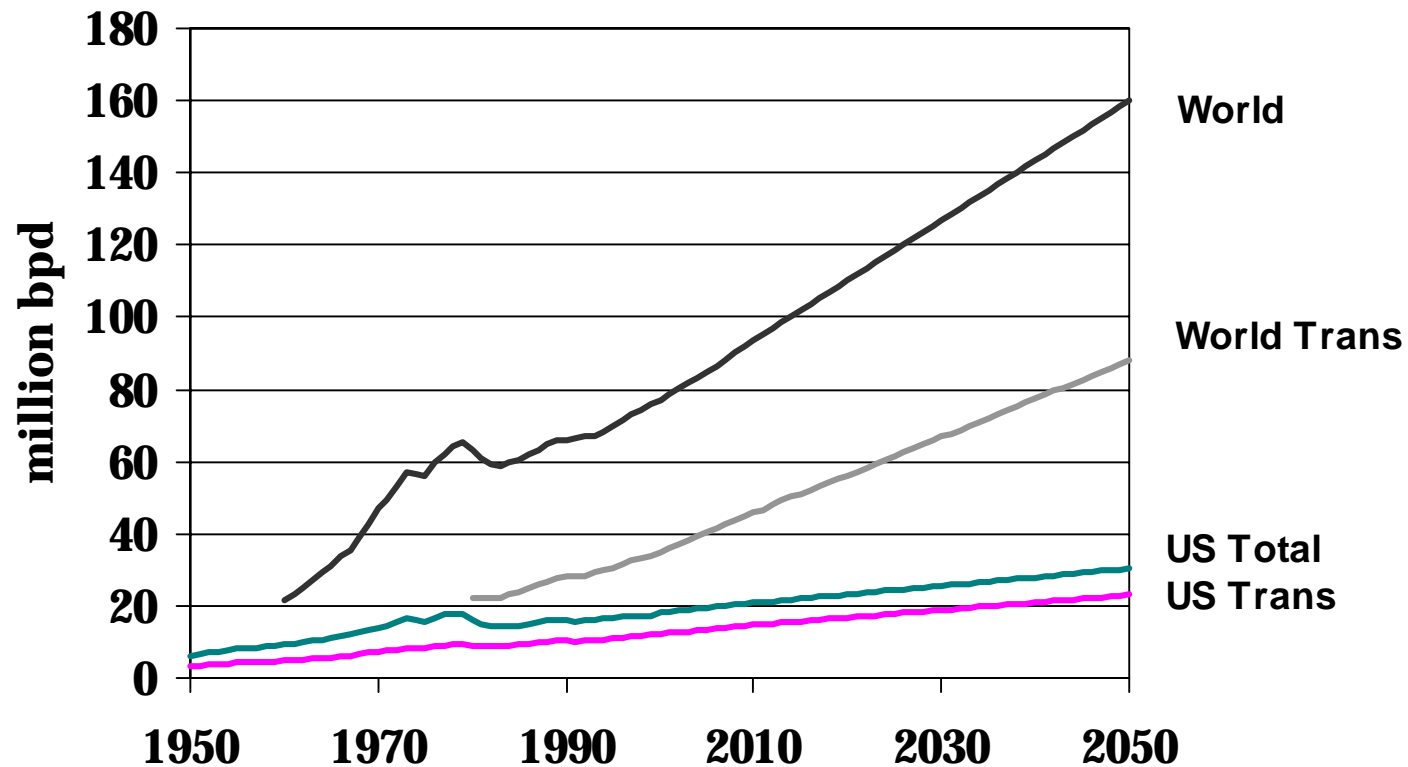
# Outline



- Oil Use and Price Projections
- The Gately World Oil Model
- Alternative Fossil Fuels
- Renewable Fuels
- Conclusions



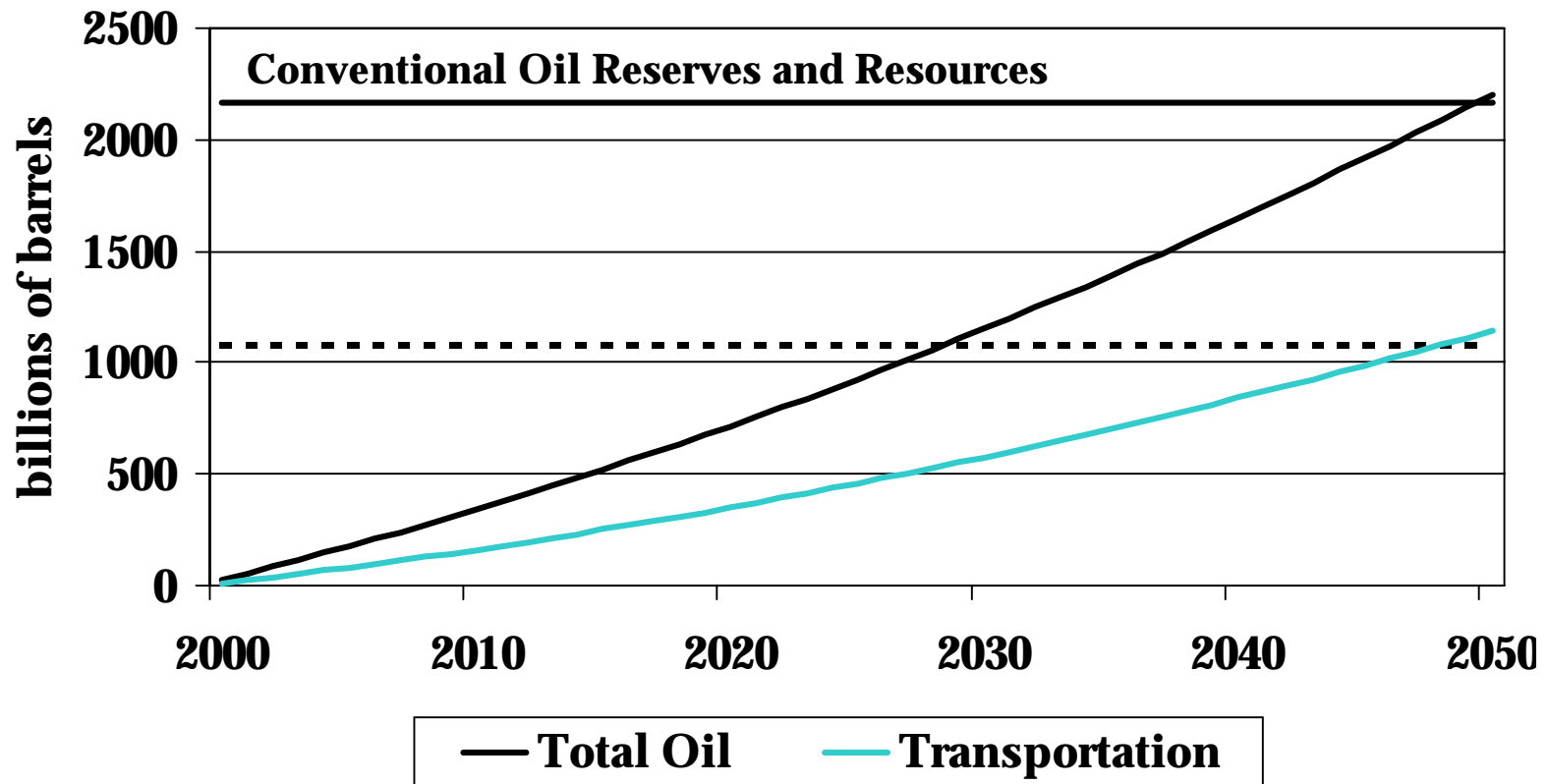
# Growth in Oil Use



Source: Years 2000-2020, World - EIA IEO'99, US - EIA AEO'00  
Years 2021-2050, World, US - extrapolation



# Oil Resources and Cumulative World Oil Use





# Factors that Affect Future Oil Price



- Population and economic growth
- End use efficiencies
- Producer actions: OPEC and OPEC+
- Price and availability of alternatives



# OPEC+



- World oil prices fell to \$9.93/barrel in January 1999.
- OPEC cut production by 1.7 million bpd.
- Mexico, Norway, Russia, and Oman collectively cut an additional 0.4 million bpd.
- The total cut amounted to only 3% of world oil production, but oil prices rebounded to \$23.69 by November 15, 1999 (DOE/EIA 1999).
- OPEC accounts for 42% of world oil production.
- "OPEC+" accounts for 62% of world oil production.
- The U.S. is the next largest producer at 9% (6 mbpd).



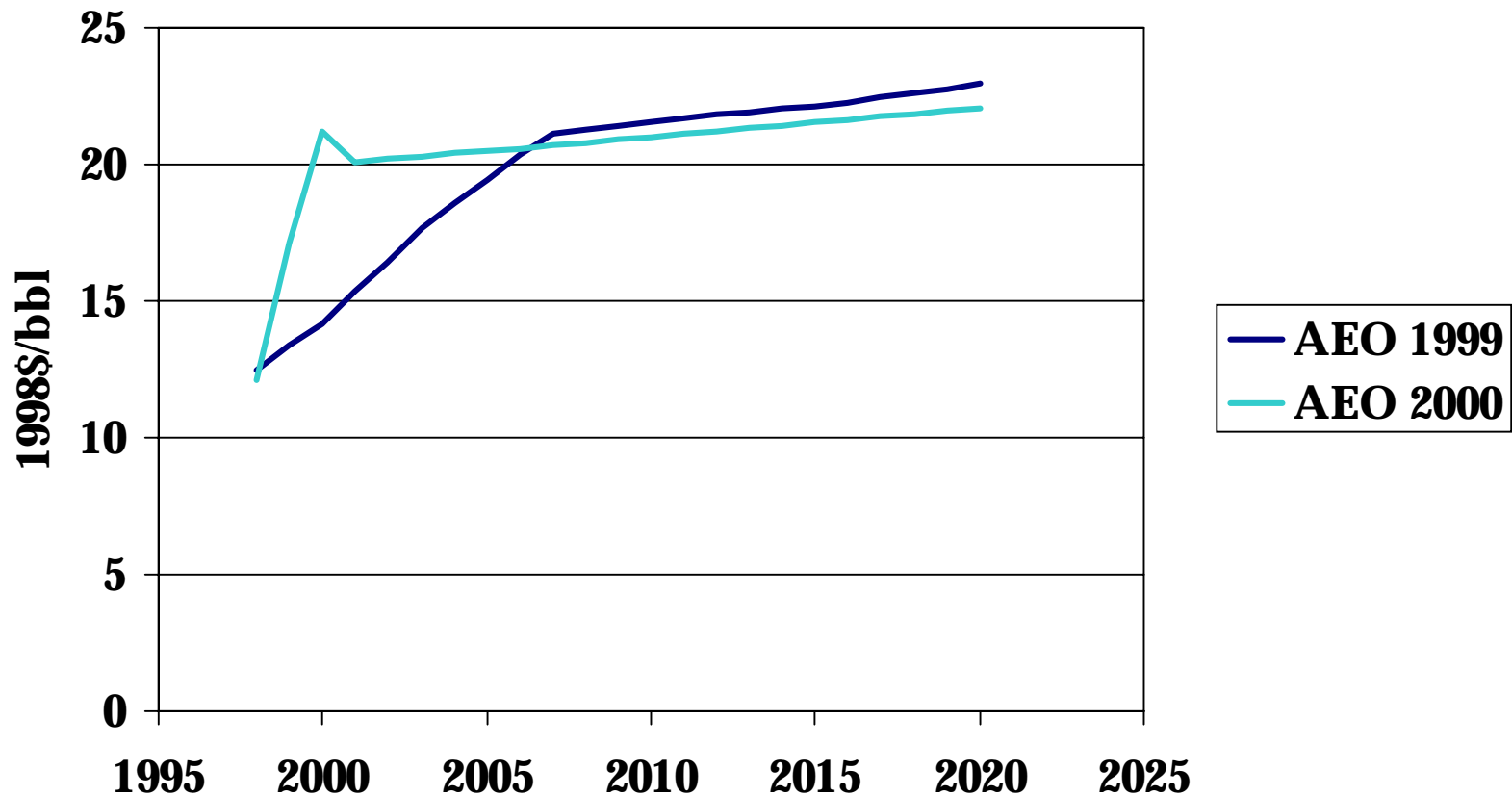
# EIA Projections: Oil Price and OPEC Production



	2020 Projections			
	AEO 1999		AEO 2000	
	Reference	High Price	Reference	High Price
<b>OPEC Production (million bpd)</b>	53.5	46.7	55.5	48.9
<b>Increase over 1997</b>	80%	57%	86%	64%
<b>World Oil Price (/bbl)</b>	\$22.73	\$29.35	\$22.04	\$28.04
<b>Revenue (billion \$)</b>	\$444	\$500	\$446	\$500



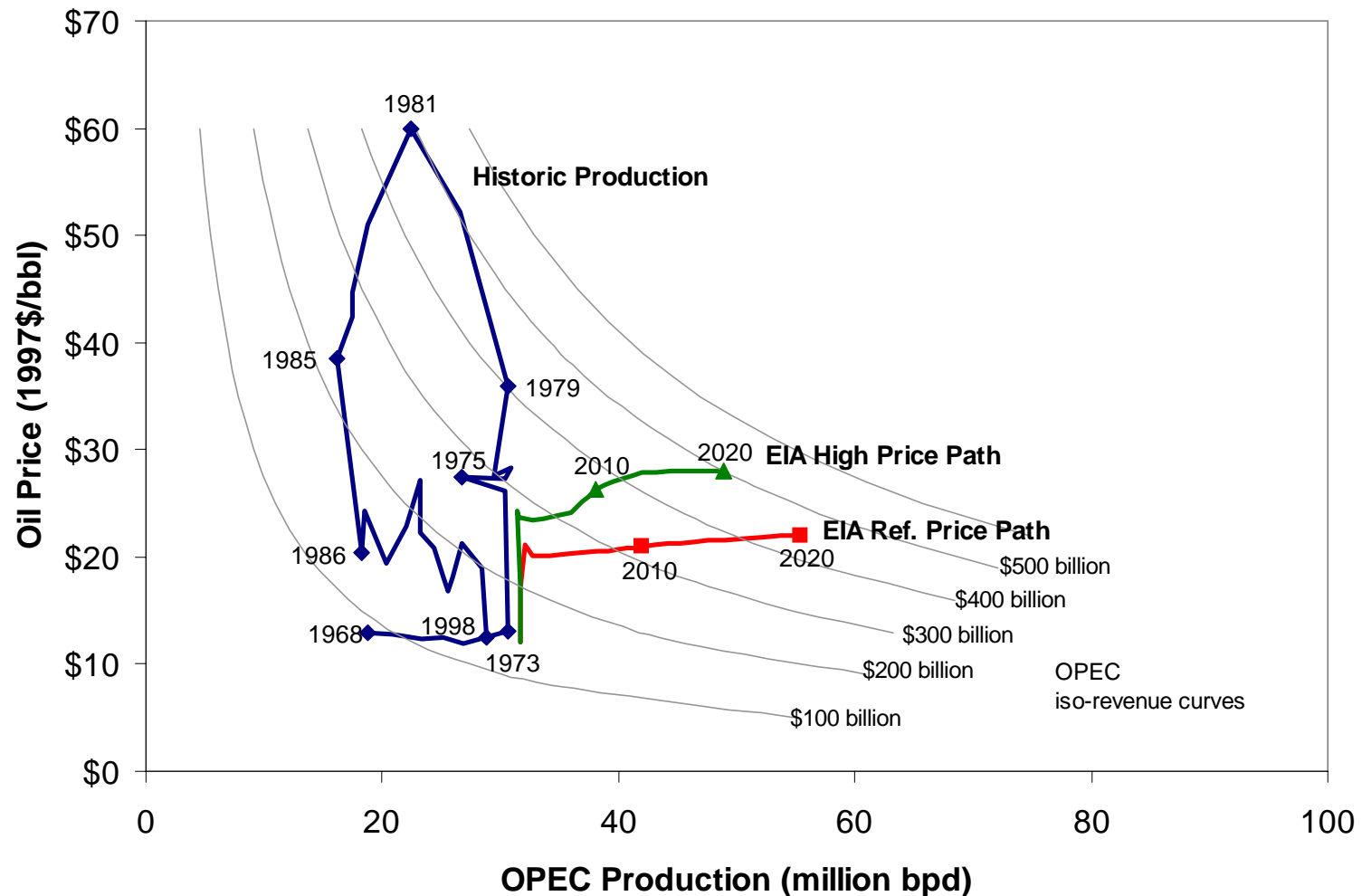
# EIA Reference Case: Oil Price Projections







# Oil Prices, OPEC Production and Revenue





# Gately World Oil Model



- Developed by Dermot Gately, NYU
- 9 world regions, same as EIA
- Oil demand
  - » determined by GDP growth, crude oil price, and lagged demand
  - » transportation & non-transportation oil
- Non-OPEC production determined by price with supply function fit to EIA Reference Case projections
- OPEC Production = World Demand - Non-OPEC Production.
- Model parameters calibrated to EIA's *International Energy Outlook 1997* (IEO) (e.g. income elasticity of oil demand).
- Current work: Recalibration to IEO 1999; Addition of gas-to-liquids fuels
- Future work: Capability to posit OPEC+ strategic behavior



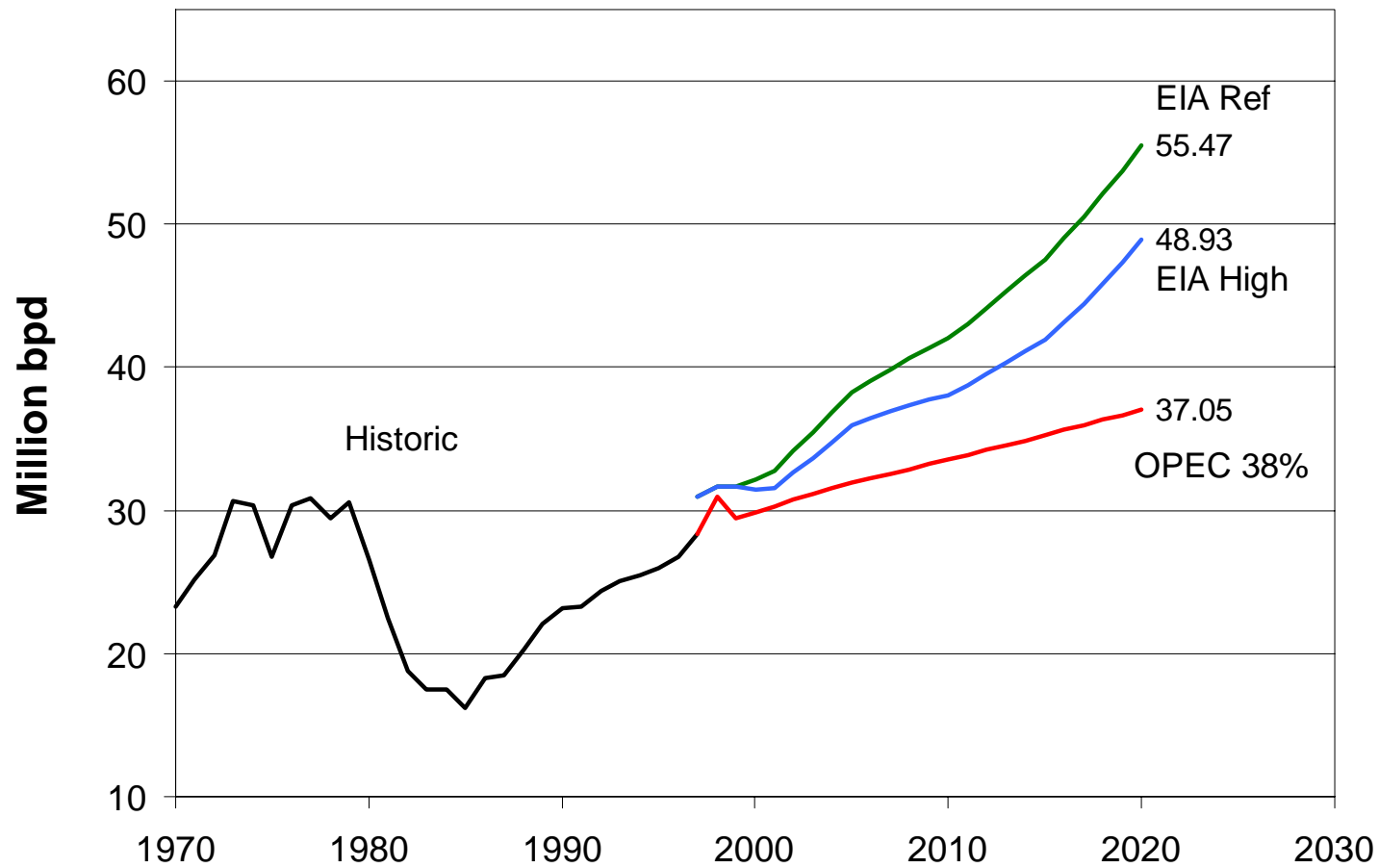
# Gately Model Capabilities



- Model Solution in either of two ways:
  - » Given price-path, calculate World Oil Demand, Non-OPEC Supply, and the required level of OPEC Output
  - » Given projected levels of OPEC Output, calculate the market-clearing price for each year such that  $\text{World Demand} - \text{Non-OPEC Supply} = \text{OPEC Output}$
- EIA's NEMS provides only the first capability, and therefore cannot analyze what production strategies are in OPEC's best interest.

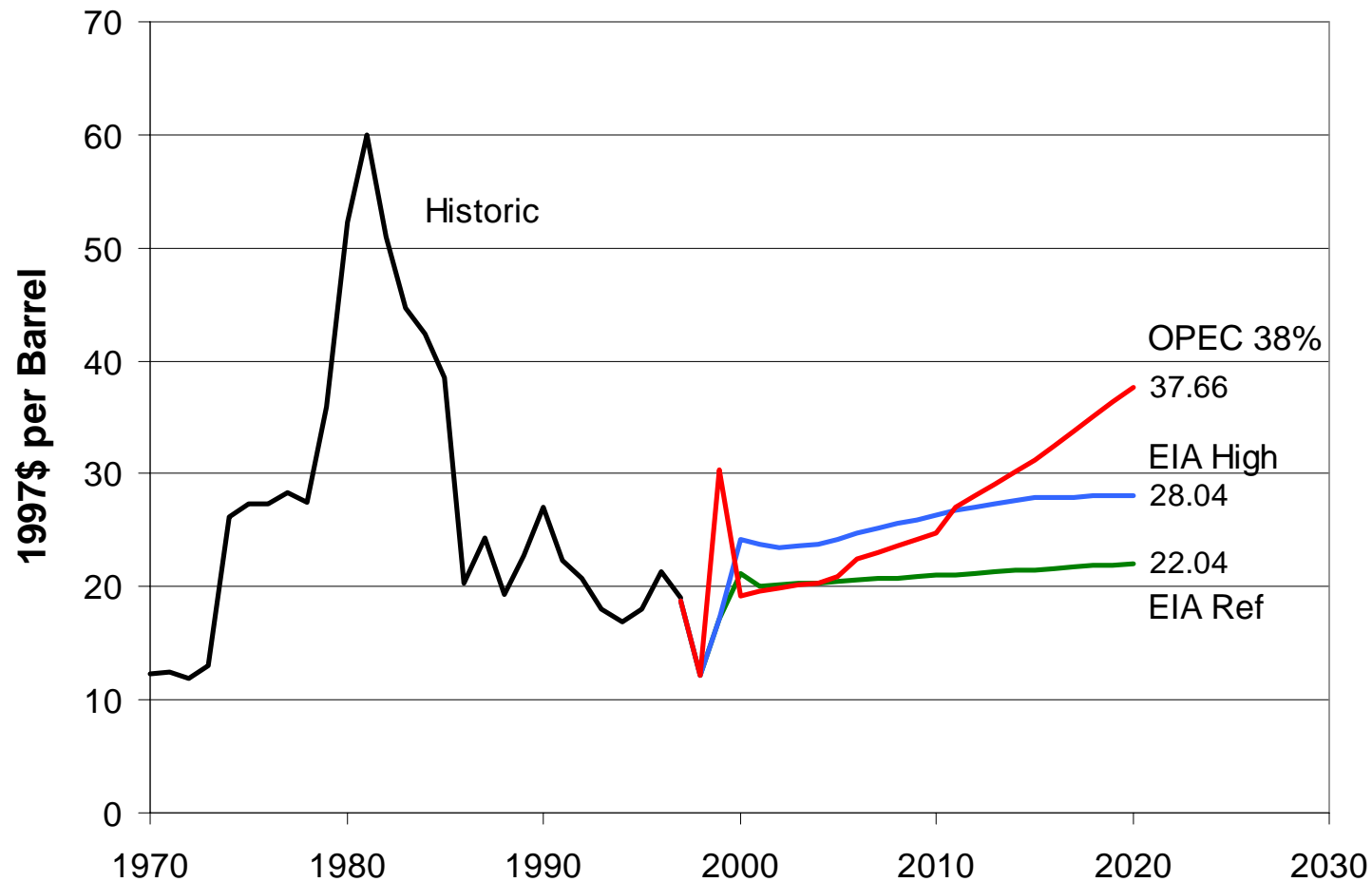


# Gately Model Results: OPEC Production





# Gately Model Results: Oil Price





# Fossil Fuel Quantities



	Billion Barrels of Oil Equivalent			
Fossil Resource	Reserves	Resources	Additional Occurrences	Total
<b>Oil</b>				
<b>Conventional</b>	1,100	1,063		2,163
<b>Unconventional</b>	1,340	2,460	13,370	17,170
<b>Natural Gas</b>				
<b>Conventional</b>	1,030	2,050		3,080
<b>Unconventional</b>	1,410	1,890	2,840	6,140
<b>Hydrates</b>			137,500	137,500
<b>Coal</b>	7,350	17,570	20,860	45,780
<b>Totals</b>	12,230	25,033	174,570	211,833

Note: Cumulative world oil use to date is <900 billion barrels.

Source: H.H. Rogner, "An Assessment of World Hydrocarbon Resources," 1997.



# Energy Stock Definitions



- Reserves - Quantities in known reservoirs that have been measured and can be extracted economically.
- Resources - Quantities that have not been measured with the same accuracy as reserves, and that may not be economically recoverable with today's technology and fuel prices.
- Additional Occurrences - Quantities with unknown degrees of assurance and unknown or speculative economic significance.



# Fuels from Natural Gas



- Compressed Natural Gas (CNG)
- Liquefied Natural Gas (LNG)
- Fischer-Tropsch Diesel (FTD)
- Methanol

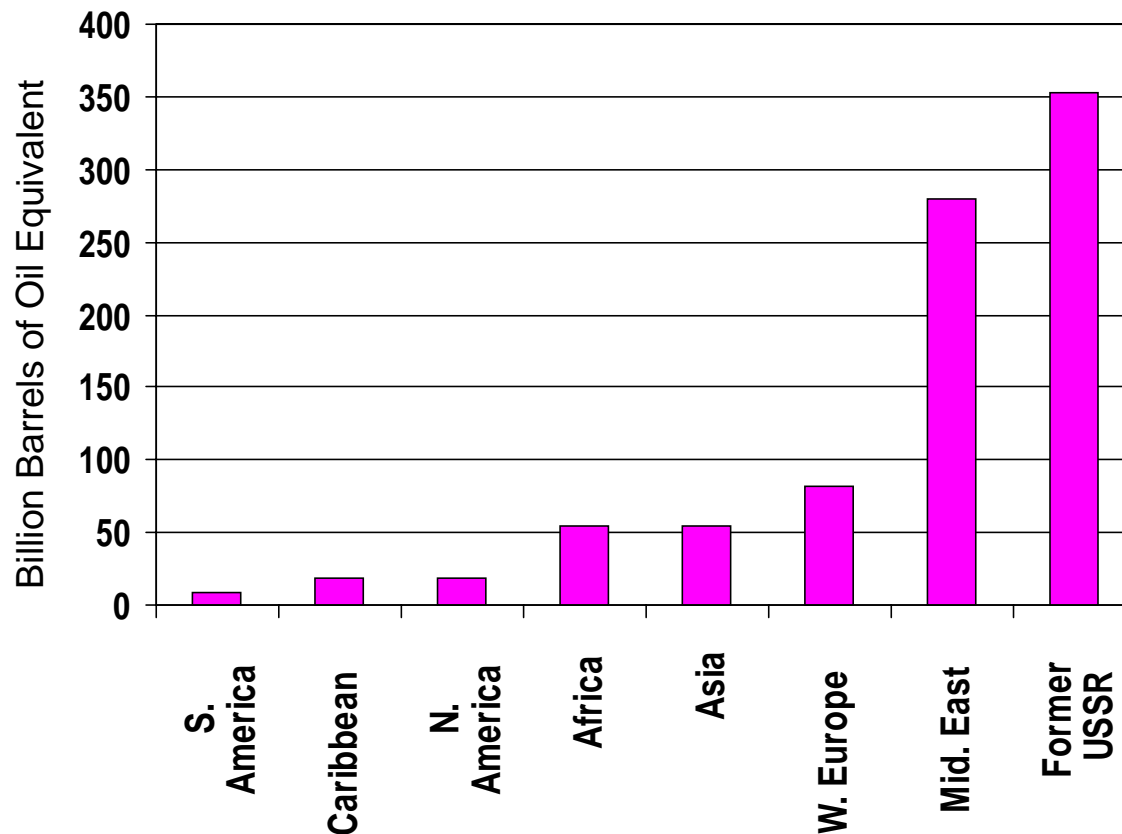




# Sources of Stranded Natural Gas



Distribution of World's Estimated 5,241 TCF  
(928 billion boe) of Stranded Gas Resource



## Stranded Gas Sources

- Remote Gas Wells & Fields

- Oil Wells

  - » Associated

  - » Dissolved

  - » Vented/Flared/Reinjected

	TCF/yr	Billion BBL/yr OE
3.8	0.67	
11.0	1.95	

- Coal Seams

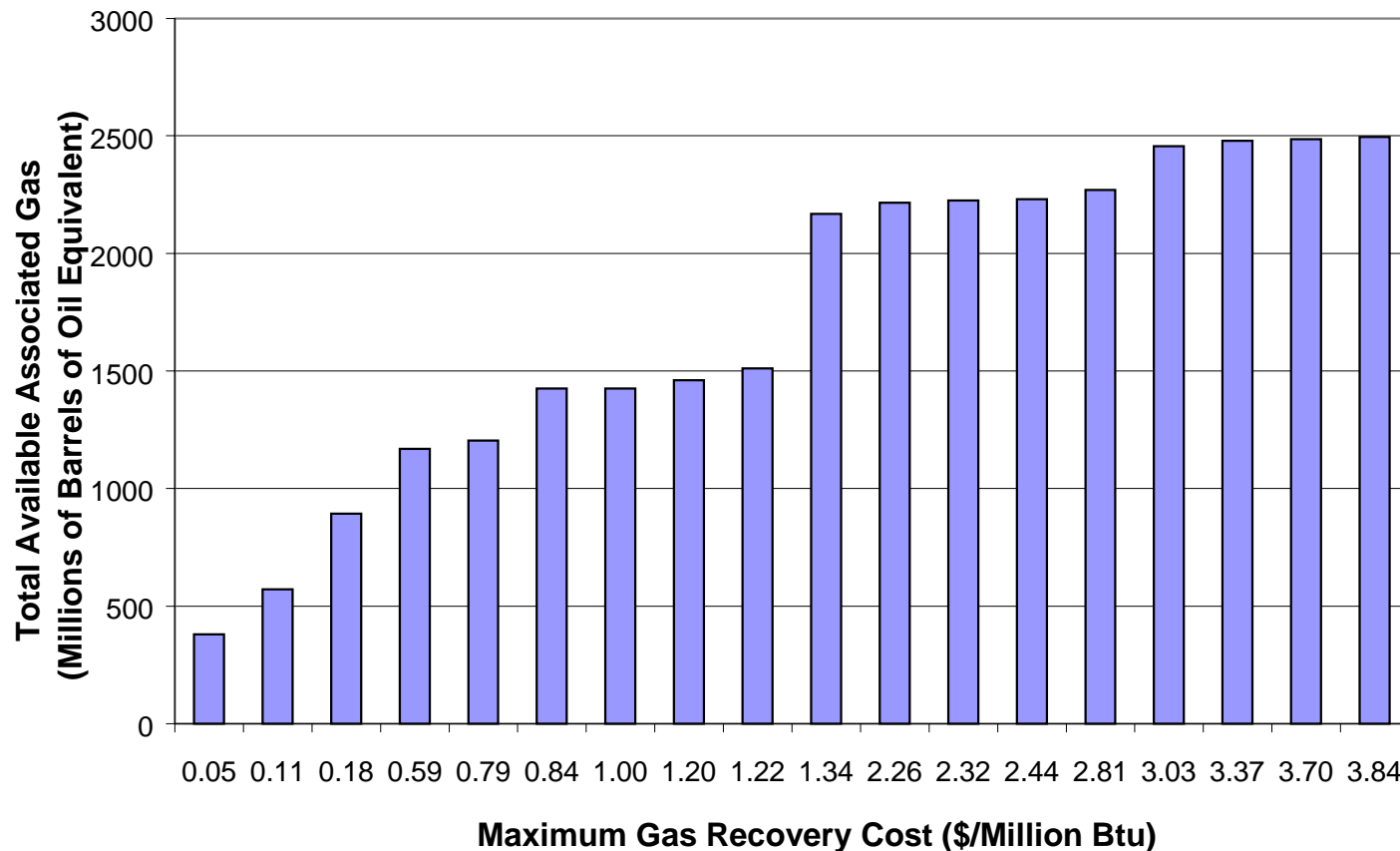
- Petroleum Refining



# World Prices and Availability of Associated Natural Gas

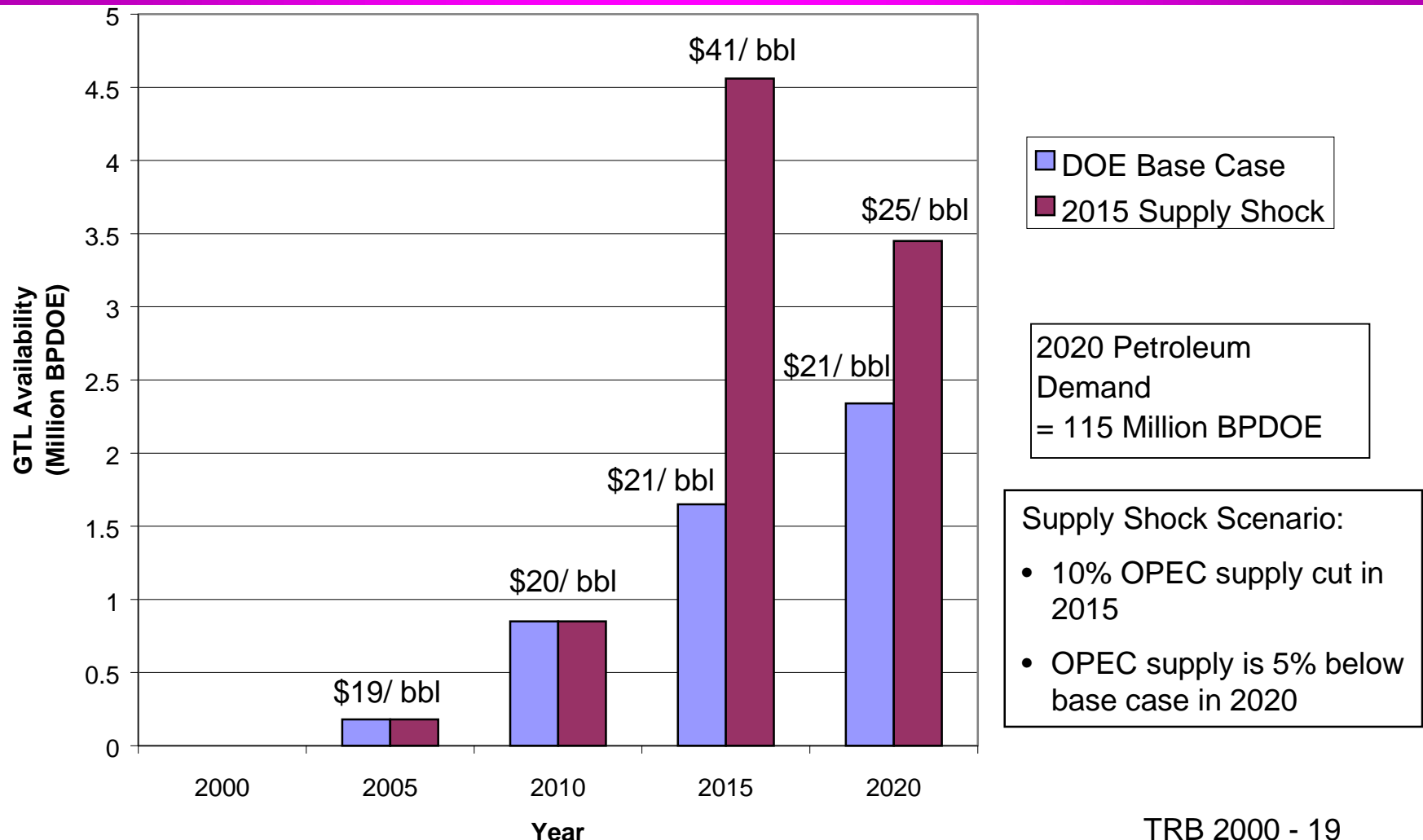


**Associated Gas Availability Vs. Price**





# Projected Availability of GTL Fuels 2000-2020: Base Case & 2015 Oil Supply Shock





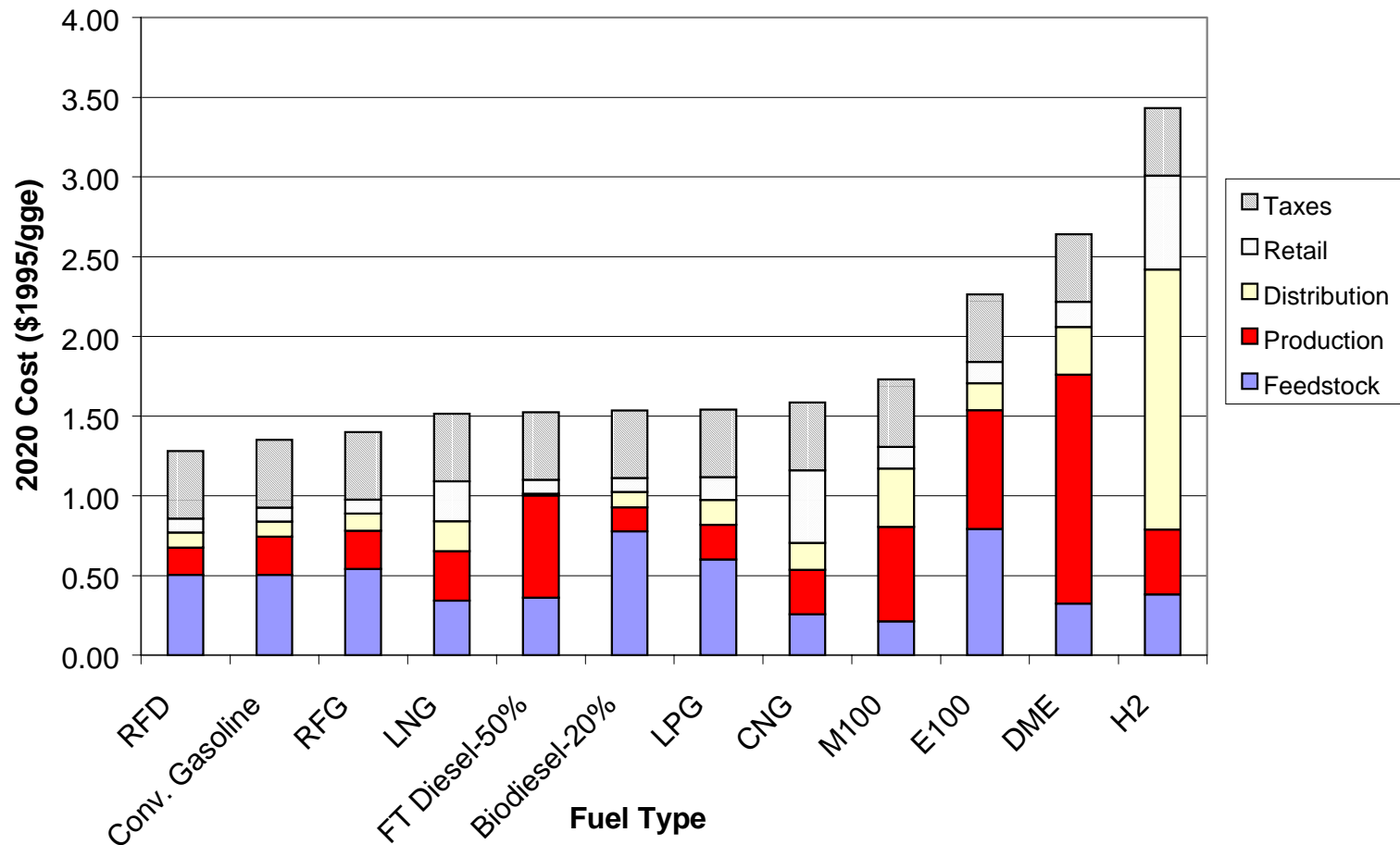
# Estimates of GTL



Source	Million bpd oil equiv.	Billion bbl/yr oil equiv.
Greene		
2015 base case	1.7	0.62
2015 oil shock case	4.5	1.64
Oil & Gas Journal		
Low	0.5	0.18
Medium	1.0-1.5	0.37-0.55
High	2.0-3.0	0.73-1.10
Arthur D. Little		
2015-2020	1.0-2.0	0.37-0.73
Further out	11.0	4.02
Alaska North Slope (2010)	0.2	0.07



# Unit Costs of Potential 3X Fuels by Cost Element (2020)



Source: Wang, PNGV Report; FTD adjusted for error in original report, as indicated by the author; taxes equalized for all fuels at \$0.424/gge.



# Renewable Fuels Cost Estimates



Fuel	Source	\$/gge
Ethanol	OTT*, 2000	1.60
	OTT*, 2020	1.15
	Wang, PNGV Report, 2020	2.22
Hydrogen	S. Thomas, Directed Technologies	1.37
	Air Products	1.64
	Wang, PNGV Report, 2020	3.43

\* cellulosic w/ ethanol subsidy



# World Ethanol Supply: Potential and Scenarios

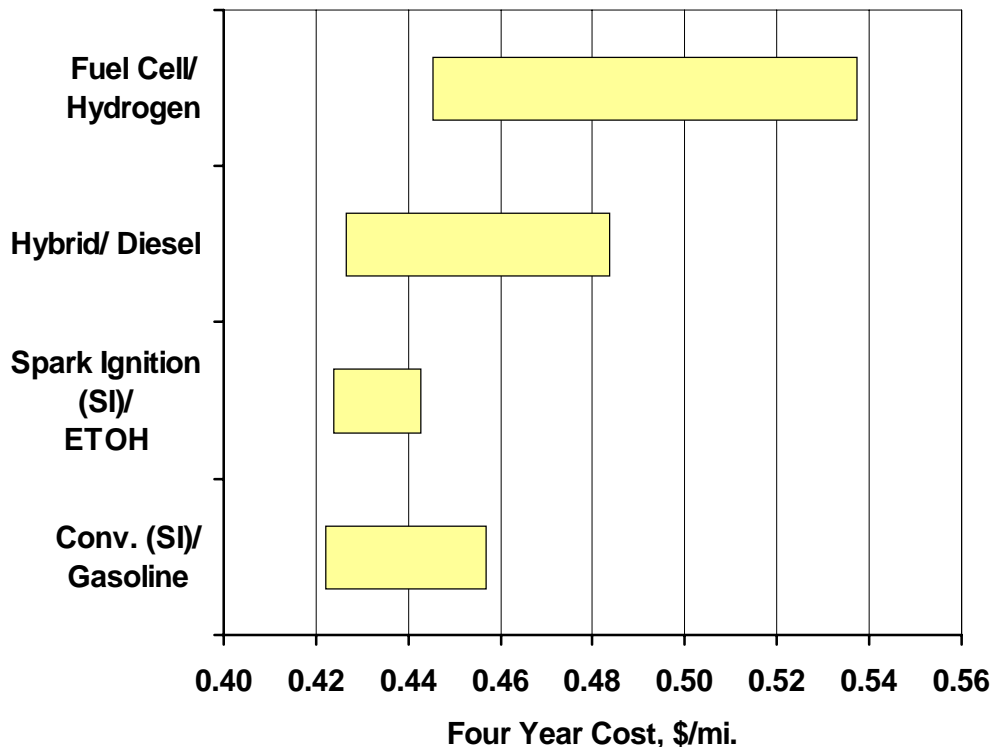


Source	Million ha	billion bbl/yr oil equiv.	Comments
<b>World</b>			
Hall - potential (constrained)	890	25	Includes residues; includes conversion losses
IIASA - Global Energy Perspectives	390-610	8-20	Scenarios A and B, 2050; energy equivalent of all commercial biomass
<b>US</b>			
Hall - potential	116	3.5	Includes Canada
DOE/ORNL - potential	208	3.0	All cropland in energy crops; low yields
OTT high case	19	0.9	Includes residues
OTT QM 2001	-	0.12	2020

*Light vehicles in the U.S. currently consume 3 billion barrels of oil  
equivalent per year.*



# Comparative Cost of Selected Technology/Fuel Combinations



- Comparisons are based on four-year present value costs for large cars.
- Fuel Costs:
  - » Gasoline: \$1.00-\$2.00/GGE
  - » ETOH: \$1.15-\$1.75/GGE
  - » F.T. Diesel: \$1.25-\$1.75/GGE
  - » H<sub>2</sub>: \$1.64-\$3.43/GGE
- Incremental Vehicle Costs:
  - » Hybrid/Diesel: 5-18%
  - » Fuel Cell/H<sub>2</sub>: 10-28%

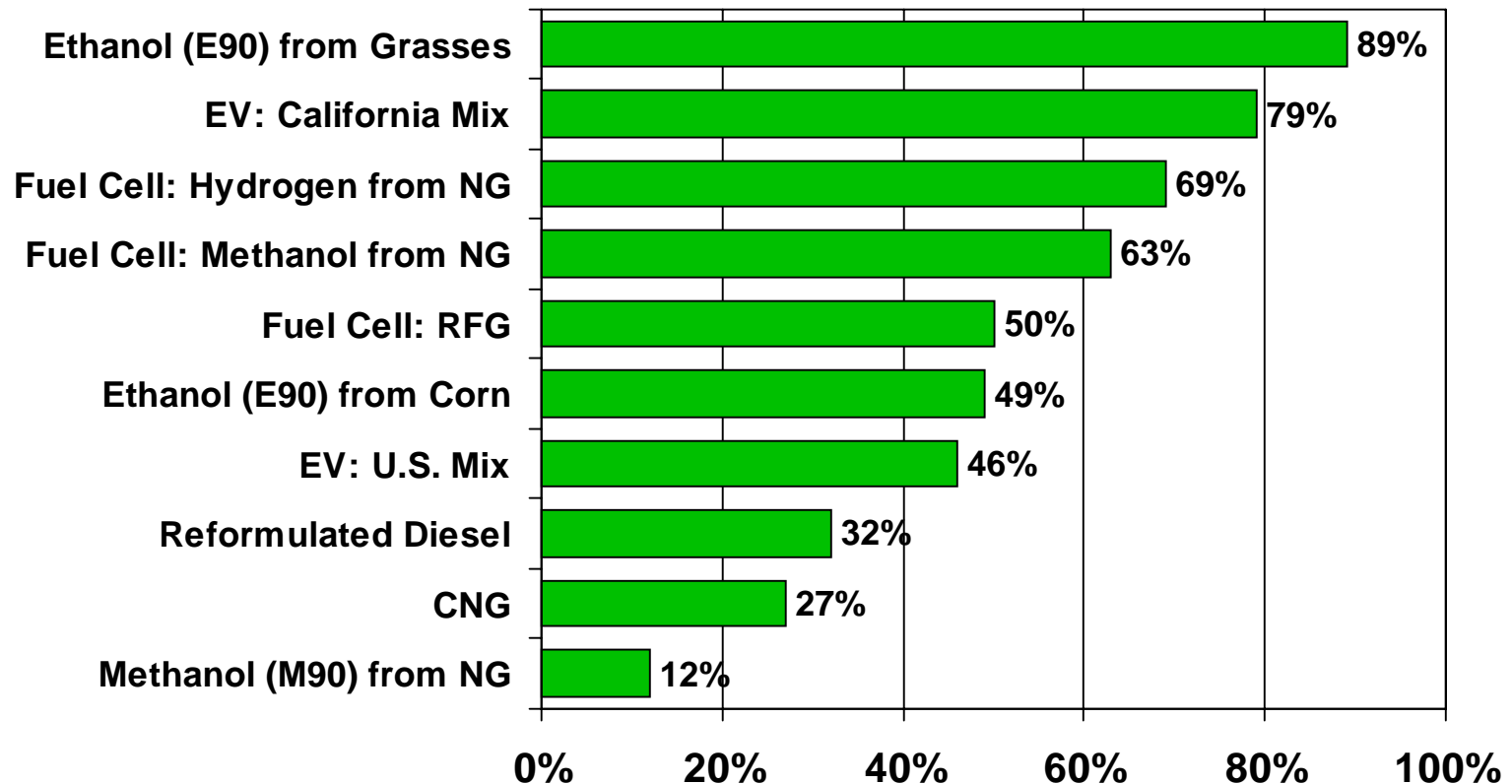




# Greenhouse Gas Emissions from Alternative Fuels



## Light Vehicle Reductions in Life-Cycle CO<sub>2</sub> Emissions





# Categories of Alternatives to Oil



	<b>Secure</b>	<b>Insecure</b>
<b>Inexpensive</b>	Conventional NG	FT Diesel Methanol Stranded NG
<b>Expensive</b>	Domestic Ethanol Renewable H <sub>2</sub> Renewable Electricity Hydrates	



# Share of World Quantities



	<b>OPEC</b>	<b>OPEC+</b>
Current Oil Production	42%	62%
Oil Reserves	78%	88%
Natural Gas Reserves	44%	80%
Vented and Flared Gas	73%	78%



# Conclusions



- Future world oil price projections by EIA may be too low.
- OPEC+ is potentially more powerful than OPEC ever was.
- GTL will be the cheapest substitutes for oil, but they may have to overcome carbon emission problems
- Renewables will need policy assistance and lower cost to be competitive.
- Better estimates are needed of resources and annual amounts of alternatives that could be available.